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CHANGE RECORD			
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1. SCOPE

This document defines the test items, and describes the test procedures of the TTCS EM μ -g performance test for the TTCS secondary loop. The test setup is placed in horizontal orientation to reduce the gravity effect as much as possible, with all the tubing dimensions (length, inner diameter, etc.) the same as those of flight model (FM).

2. DOCUMENTS


Table 2-1

RD-1	TTCS EM Test Plan	AMSTR-NLR-TN-04 7	
RD-2	TTCS EM TTCS Items under test		
RD-3	TTCS EM Test Facility Description		
RD-4	Cleaning of 316L tubes and Components	TTCS-SYSU-GS-RP -001-1.0	
RD-5	LEAK DETECTION FOR TTCS EM BY HE MASS SPECTROGRAPH	TTCS-SYSU-GS-TN -003-1.0	
RD-6	CO2 FILLING PROCEDURE FOR TTCS	TTCS-SYSU-GS-TN -002-1.0	

3. TEST OBJECTIVES

The objectives of the TTCS EM μ -g performance test for secondary loop is to perform the test in simulated environments of space orbits, including:

- To verify the TTCS operations in microgravity, and in nominal orbital conditions
- To verify the TTCS operations in microgravity, and in extreme orbital conditions

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- To check the TTCS start-up function in cold and hot orbital conditions
- To check the TTCS components thermal responses to control action

4. HARDWARE UNDER TEST

4.1 TTCS EM secondary loop configuration

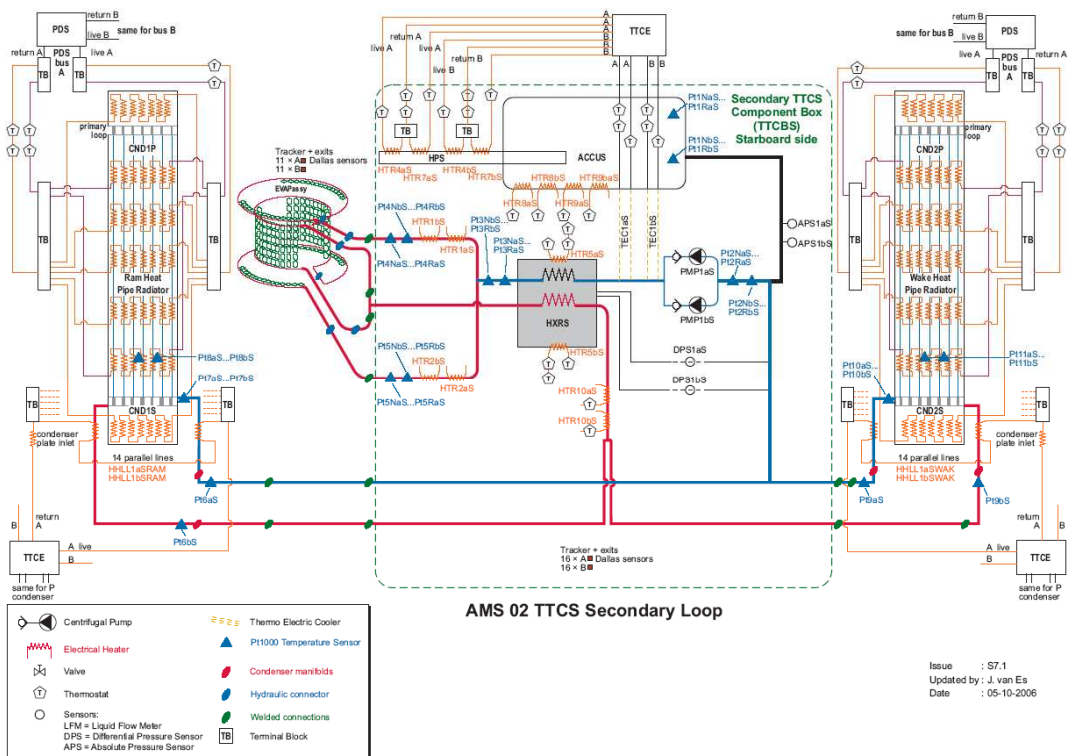



Figure 4-1 TTCS secondary loop schematics

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AMS 02 TTCS Secondary Loop
Piping sizes and lengths

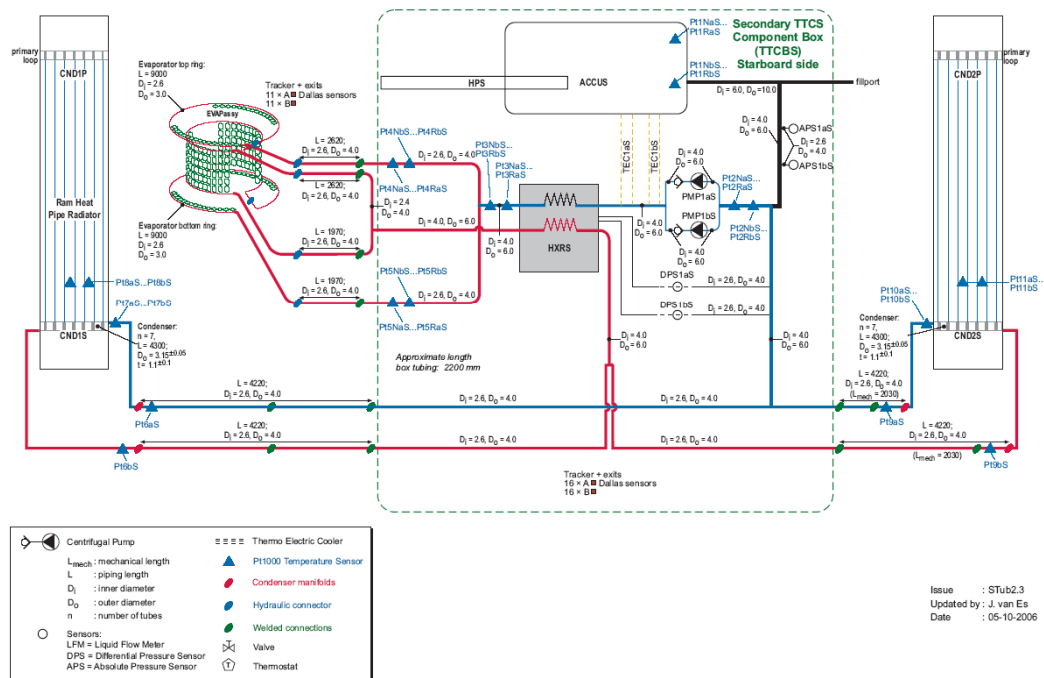


Figure 4-2 TTCS secondary loop piping lay-out

4.2 Hardware under test

The TTCS secondary loop, which consists of components, such as accumulator, pump, heat exchanger, evaporators, and condensers, is under test. Some component tests, such as pump performance test, are included in the TTCS EM secondary loop μ -g test.

See RD-2

(To be continued)


5. TEST REQUIREMENT

See RD-2


Table 5-1 Test requirements for μ -g secondary loop test

Requirement ID	Requirement Description	Verification Method
Loop Performance		


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LP-01	Evaporator temperature stability ≤3K per orbit	Test
LP-02	Tracker cooling capacity P≥154W	Test
LP-03	Performance at environmental extremes (tracker operational) <ul style="list-style-type: none"> Cold orbits $T_{HB} \geq -12C$ Hot orbits $T_{HB} \leq +25C$ 	Test and Analysis*
LP-04	Performance at environmental extremes (tracker non-operational) <ul style="list-style-type: none"> Cold orbits $T_{HB} \geq -20C$ Hot orbits $T_{HB} \leq +40C$ 	Test and Analysis*
LP-05	Accumulator set-point change <ul style="list-style-type: none"> Increase (1K/min TBC) Decrease (0.5K/min TBC) 	Test
LP-06	Mass flow rate adjustments (from 1g/s to 4g/s)	Test
LP-07	TTCS start-up in cold conditions $T_{HB} \geq -20C$	Test
LP-08	TTCS start-up in hot conditions $T_{HB} \leq +40C$	Test
LP-09	Flawless TTCS operation during tracker start-up in cold conditions	Test
LP-10	Flawless TTCS operation during tracker start-up in hot conditions	Test
LP-11	Flawless TTCS operation during tracker shutdown in cold conditions	Test
LP-12	Flawless TTCS operation during tracker shutdown in hot conditions	Test
LP-13	Pressure drop in μ -g operation <ul style="list-style-type: none"> ≤150mbar@1g/s hot ≤850mbar@4g/s hot ≤150mbar@1g/s cold ≤850mbar@4g/s cold 	Test
LP-15	Extreme temperature gradient operation?? <ul style="list-style-type: none"> Highest positive T-gradient (orbit) Highest negative T-gradient (orbit) 	Test
LP-16	Show flawless operation at 50% Tracker heater Imbalance	Test
LP-20	Accumulator liquid level ?? <ul style="list-style-type: none"> Check in cold conditions Check in hot conditions 	Test and Analysis*
Control Scenarios		

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LP-22	Accumulator control <ul style="list-style-type: none"> Control heater control to keep evaporator temperature stability within 3K/orbit Emergency heater control to check the maximal heating rate in hot cases 	Test
LP-23	Pre-heater control <ul style="list-style-type: none"> Proper control in operating range (to check on/off response) 	Test
LP-24	Start-up heater control <ul style="list-style-type: none"> Proper control in operating range (to check on/off response and if evaporator inlet temperature meet the start-up requirement of -20C) 	Test
LP-25	Cold orbit heater control <ul style="list-style-type: none"> Proper control in operating range (to check on/off response of the pump inlet temperature to the control action) 	Test
LP-26	Pump inlet temperature subcooling margin safeguard <ul style="list-style-type: none"> Proper function Check, if possible, the relation between the subcooling margin and the bubble formation through the pump. 	
LP-27	Tracker temperature too low safeguard <ul style="list-style-type: none"> Proper function: if the temperature of the evaporator is too low, the pump, and thus the TTCS system, will be turned off. 	Test
LP-28	APS/DPS operation in loop <ul style="list-style-type: none"> Proper function: relation between the APS reading the set-point temperature (of the accumulator); between DPS reading and flow rate in different cases. 	Test
LP-29	Pump cooling in loop <ul style="list-style-type: none"> Check Housing T- change after (supercritical) start-up. 	Test
LP-32	Thermal switch location (define the TS location before the test) $T_{Operation} \leq T_{Switch}$ Select thermal switch locations (on the accumulator, cold orbit heater, etc.), and check the TTCS system can run at any operational condition without being interrupted by the thermal switch)	Test
Power Consumption		
PW-01	Power consumption of the pump in the loop (without pump controller), those including pump controller will be tested in QM test	Test
PW-02	Pre-heater power consumption: 8W	Test
PW-03	Cold orbit heater power consumption: 60W	Test

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PW-04	Start-up heater power consumption: 50W	Test
PW-06	Accumulator heater power consumption <ul style="list-style-type: none"> Control heaters (measure the fully-on maximum power consumption at operation voltage,) 37.5W * 	Test

As there is no Tracker, nor Tracker Hybrid, the Hybrid temperature (T_{HB}) requirement can only be checked by analysis together with the checked temperature of the evaporators. We will measure the temperature of the heaters (hybrid simulators), and take into account the temperature of difference across the carbon fibre bars (2°C?) [LP-03, LP-04]

Due to the complication of the Accumulator Wick structure, it is unlikely to perform accurate measurement of the CO₂ liquid level inside the accumulator. Here, only an attempt will be taken to see if a precision of 10mm can be achieved. [LP-20]

* for micro-g test, two foil heaters are in parallel to provide 37.5W (voltage= 22.5V); for 3-d test, only one foil heater is used to provide 37.5W (voltage= 32V).

6. GENERAL TEST CONDITIONS AND TOLERANCE LEVELS


See RD-2

During verification by test a number of general conditions will be respected. Also the tolerance of the measured values and the monitoring of the environmental conditions are specified.

6.1 General test conditions

Unless otherwise specified, all the tests should be carried out within the following ambient conditions:

- Temperature 15°C to 30°C
- Relative humidity 30% to 70%
- Pressure 750mbar to 1060mbar
- Environment Cleanliness visibly clean

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6.2 Tolerance levels

The maximum tolerances on general test conditions and parameters measured should be as presented in the next table, unless otherwise mentioned in the test procedure.

Table 6-1 Test tolerances

Parameter	Measurement Rang	Tolerances
Temperature		
Thermocouples	-100°C to +100°C	±0.7°C
	-200°C to -100°C	±3°C
Pt1000	-50°C to +100°C	±0.20°C
	100°C to 250°C	±0.5°C
Relative Humidity		±5%
Time		±2%
Electrical Power		
DC-Current	0-10A	0.1%
DC-Voltage	0-100V	0.1%
Absolute Pressure	0-65 bar	1%
Differential Pressure	1-5 bar	1%
	100 mbar to 1 bar	1%
	1 mbar to 100mbar	1%

7. TEST FACILITY AND RESPONSIBILITIES

7.1 Test facility


See RD-4

7.2 Responsibilities

The following Test Personnel are assigned for the test

- Test Manager: Zhenhui He/T.L. Li
- Product Assurance Representative: Shushen Lv
- Test Engineer: Wenjia Xiao

See RD-2

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The **Test Manager** is responsible for the execution of the tests in accordance with the test procedures.

The **Product Assurance Representative** is responsible for witnessing of the test. Both parties are responsible for evaluation of the test results.

The **Test Engineer(s)** perform(s) all activities related to the environmental test system such as preparing the test set-up and completing the test log-sheets concerning the (environmental) test itself (i.e vacuum levels, chamber T's, humidity, etc).

The **Test Engineer(s)** also perform(s) all activities related to the test sample as running the functional tests, printing the output from the functional tests, building up the related functional test set-up, completing the log-sheets concerning the behaviour of the test sample and the result of the various steps in this test plan.


Interpretation of test results is the responsibility of the **Test Engineer(s)** involved.

8. MICRO-G TEST ITEMS FOR THE TTCS SECONDARY LOOP

See RD-2.


Check nominal operation controls
Check accumulator control heater control
Check accumulator TEC control
Check pump control
Check heater and component power consumption
Check the pressure drop and mass flow rate at different pump speeds (3000, 5000, 7500, 10000 rpm)

Switch on/off Star Tracker simulator and check Tracker Temperature stability (while carefully monitoring the mass flow)
Switch on/off cold orbit heater and check Tracker Temperature stability (while carefully monitoring the mass flow)
Perform Temperature check on TS location Cold Orbit Heater


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Switch on/off start-up heater and check Tracker Temperature stability (while carefully monitoring the mass flow)
Perform Temperature check on TS location HX
Switch on/off liquid line health heaters and check Tracker Temperature stability (carefully monitor mass flow) ??
Vary heat load and check Tracker Temperature stability (while carefully monitoring the mass flow)


Test Item Description		
Nominal operation conditions test (moderate orbit)		
TTCS Functional Check		
Step		Req. Verification
Check nominal operation controls		LP-22, LP-23, LP-1, LP-06
1	Check APS, DPS signals	LP-28
2	Check temperature sensor outputs	
3	Check accumulator control heater control	LP-22
4	Check accumulator TEC control	LP-22
5	Check pump control	LP-06
6	Check heater and component power consumption	PW-01, PW-02, PW-03, PW-04, PW-06, PW-07
7	Check the pressure drop and mass flow rate at different pump speeds (3000, 5000, 7500, 10000 rpm)	LP-13
Nominal operation conditions test (moderate orbit)		
1	Switch on/off Star Tracker simulator and check Tracker Temperature stability (while carefully monitoring the mass flow)	LP-01
2	Switch on/off cold orbit heater and check Tracker Temperature stability (while carefully monitoring the mass flow)	LP-01, LP-25

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3	Perform Temperature measurement on the Cold Orbit Heater (saddle) and check the TS location	LP-32, PW-03	LP-25,
4	Switch on/off start-up heater and check Tracker Temperature stability (while carefully monitoring the mass flow)	LP-01, LP-24	
5	Check evaporator temperature stability under a rapid change of condenser temperature (both heating and cooling)	LP-15	
6	Perform Temperature measurement on the HX and check the TS location	LP-32, PW-04	LP-24,
7	Vary heat load and check Tracker Temperature stability (while carefully monitoring the mass flow)	LP-01, LP-02	
8	Perform heater imbalance test (50% imbalance between upper and lower Tracker rings)	LP-16, LP-02	LP-01,
9	Shutdown TTCS Pump Test	LP-12	
Hottest orbit operations test			
1	Perform pressure drop check before and after tracker start-up (test for the system at different mass flow rate)	LP-13	
2	Check the pressure drop and mass flow rate at different pump speeds (3000, 5000, 7500, 10000rpm) (test for the pump)	LP-13	
3	Perform heater imbalance test (50%) imbalance between upper and lower Tracker rings)	LP-16, LP-02	LP-01,
4	Perform Tracker start-up in hot orbit and operation test	LP-08, LP-10	
5	Perform Tracker shutdown test	LP-12	
6	Measure the Temperature on (All Accu TS, HX TS, Cold orbit TS) and check the TS locations	LP-32	
7	Check evaporator temperature stability under a rapid change of condenser temperature (both heating and cooling)	LP-15	
Hottest orbit +5K margin test			
1	Perform pressure drop check before and after tracker start-up (test for the system at different mass flow rate)	LP-13	
2	Perform heater imbalance test (50% imbalance between upper and lower Tracker rings)	LP-16, LP-02	LP-01,

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3	Perform Tracker start-up and operation test	LP-08, LP-10
4	Perform Tracker shutdown test	LP-12
5	Measure the Temperature on (All Accu TS, HX TS, Cold orbit TS) and check the TS locations	LP-32
6	Check evaporator temperature stability under a rapid change of condenser temperature (both heating and cooling)	LP-15
Coldest orbit operations test		
1	Check the cold orbit heater control (on Pump inlet control Pt2	LP-25
2	Perform check on the start-up heater control	LP-24
3	Perform pressure drop check before and after tracker start-up (test for the system at different mass flow rate)	LP-13
4	Check the pressure drop and mass flow rate at different pump speeds (3000, 5000, 7500, 10000rpm) (test for the pump)	LP-13
5	Perform heater imbalance test (50%) imbalance between upper and lower Tracker rings)	LP-16, LP-01, L-02
6	Perform Tracker shutdown test	LP-11
7	Perform Tracker start-up test	LP-07
8	Check evaporator temperature stability under a rapid change of condenser temperature (both heating and cooling)	LP-15
Coldest orbit -11K margin test (TBDefined)		
1	Check the cold orbit heater control (on Pump inlet control Pt2)	LP-25
2	Perform check on the start-up heater control	LP-24
3	Perform pressure drop check before and after tracker start-up (test for the system at different mass flow rate)	LP-13
4	Check the pressure drop and mass flow rate at different pump speeds (3000, 5000, 7500, 10000rpm) (test for the pump)	LP-13
5	Perform heater imbalance test (50% imbalance between upper and lower Tracker rings)	LP-16, LP-01, LP-02
6	Perform Tracker shutdown test	LP-11
7	Perform Tracker start-up test	LP-07

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8	Check evaporator temperature stability under a rapid change of condenser temperature (both heating and cooling)	LP-15
Set-point change testing		
1	Perform maximum set-point increase test (orbit change TBD)	LP-05
2	Perform maximum set-point decrease test (orbit change TBD)	LP-05
Perform TS protected heater RC-time measurements		
1	Perform RC-time and temperature rise measurement of <u>start-up heaters</u> (implement max T_{alert})	
2	Perform RC-time and temperature rise measurement of <u>cold orbit heaters</u> (implement max T_{alert})	
Perform checks on healthguards (possibly can be implemented after cold or hot orbit tests)		
1	Tracker Temperature too low safeguard check (to tailor control set-point)	LP-27
Perform start up test ???		
1	Supercritical pump start up	LP-08

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9. TEST PROCEDURE IN MAIN STEPS

During the test, the following procedures should be followed.

9.1 Preparation

Before the loop test starting, the following preparation should be finished.


Step	Action	Time required
1	Leak test according to RD-6	2 days
2	Filling CO ₂ with required mass and sealing the loop RD-6	1 day
3	Functional check of the loop, including sensor readings and all the control responses of the components	0.5 days
4	Measure heat leak to environment (with stationary radiator temperature) and thermal balance test for three cases (hottest, coldest, and nominal)	2.5 days
5	Thermal switch location Check	0.5 day
6	Function check of safeguard	0.5 days
7	total	7 days

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9.2 Nominal operation condition test

The test procedures in nominal operation condition test are described as follow.


Step	Action	Req. Verification
1	Record the ambient temperature, atmospheric pressure and humidity of the cleaning room	Section 6.1
2	Turn on the data-acquisition and control system.	
3	<ul style="list-style-type: none"> Run the walk-in climate chamber temperature at Tset=0°C Run bench-top climate chamber at the lowest value (= -30°C) of the moderate orbit temperature profiles (what is the moderate orbit temperature profile of the condensers). 	
4	Run the cold plates with set temperature profile (as shown in Figure 9.1.1) of moderate orbits.	
5	Start USS simulator temperature control and set USS temperature to nominal orbit case (=5°C)	
6	Start accumulator temperature control (heater/TEC control) and set the accumulator temperature 5°C (that is subcooling) above the temperature of pump inlet , to ensure the loop is filled with liquid	
7	Check pump inlet subcooling ≥5°C	
8	Start the cold orbit heater auto control mode. #	
9	Start pump control and run pump at 5000rpm after the subcooling of 5°C is achieved	
10	Change the accumulator temperature to Tset=0°C (make sure the subcooling≥5°C is achieved during this process)	

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11	Switch on the pre-heaters (8W*2) and check their power by $P=V*I$	PW-02
12	Turn on the heat load of 144W (72W for each ring) and run the loop for 3 hours (two cycles)	LP-02
13	Vary heat load and check evaporator temperature stability (4.5 hours)	LP-01, LP-02
	1. Change the Tracker heat load from 144W to 220W (110W for each ring) and while running the loop and measure the evaporator temperature for 1.5 hours 2. Change the Tracker heat load from 220W to 100W and run the loop for 1.5 hours 3. Change the heat load back to 144W from 100W and run the loop for 1.5 hours	
14	Check the pressure drop at different pump speeds (3000, 5000, 7500, 10000rpm) (2.5 hours)	LP-13, LP-06
	1. Change the pump speed to 3000rpm and run the loop for 1.5 hours and record the pressure drop 2. Change the pump speed from 3000 to 5000rpm and run the loop for 10 minutes and record the pressure drop for 10 minutes 3. Change the pump speed from 5000 to 7500rpm and run the loop for 10 minutes and record the pressure drop 4. Change the pump speed from 7500 to 10000rpm and run the loop for 10 minutes and record the pressure drop for 10 minutes 5. Adjust the pump speed to 5000rpm and run the loop for 30 minutes	
15	Heater imbalance test (50% imbalance between upper and lower tracker rings) $(P_{up}-P_{down})/(P_{up}+P_{down})=50\%$ (6 hours)	LP-16
	1. Increase the heat load to top evaporator to 108W and decrease the heat load to bottom evaporator to 36W gradually until 50% imbalance is obtained otherwise the temperature of the evaporator loses its required uniformity and then run the loop for 3 hours 2. Decrease the heat load to top evaporator to 36W and increase the heat load to bottom evaporator to 108W gradually until 50% imbalance is obtained otherwise the temperature of the evaporator loses its required uniformity and then run the loop for 3 hours	

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16	Change the heat load back to 72W for each ring and run the loop for 1.5 hours	
17	Switch on/off star tracker simulator and check evaporator temperature stability (1.5 hours)	LP-01, LP-02
	1. Switch on star tracker simulator of 6.8W and run the loop for 20 minutes 2. Switch off star tracker simulator and run the loop for 20 minutes 3. Repeat step 1 and 2 twice	
18	Switch on/off cold orbit heater and check evaporator temperature stability (1.5 hours)	LP-01, LP-02
	1. Change the Cold Orbit Heater to manual control mode and switch on Cold Orbit Heater of 60W and run the loop for 20 minutes 2. Switch off Cold Orbit Heater and run the loop for 20 minutes 3. Repeat step 1 and 2 twice 4. Change the Cold Orbit Heater control mode back to auto 5. Obtain responses delay of pump inlet temperature, condenser temperature to the cold orbit heater	
19	Switch on/off start-up heater and check evaporator temperature stability	LP-01, LP-02
	1. Switch on Start-up Heater of 50W and run the loop for 20 minutes 2. Switch off Start-up Heater and run the loop for 20 minutes 3. Repeat step 1 and 2 twice	
20	Loop stability and responses check to the rapid change of condenser temperature	LP-15
	1. Set a temperature profile to the cold plates with maximum temperature change rates of both positive (heating) and negative (cooling) 2. Check the loop responses and stability	
21	Turn off the Tracker heat load	If no other orbit

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		condition is tested
22	Turn off pre-heaters	
23	Shutdown TTCS Pump (Shutdown TTCS pump test)	
24	Turn off accumulator temperature control	
25	Shut down the cold orbit heater control	
26	Turn off USS temperature control	
27	Turn off the cold plates temperature control	
28	Set the bench-top climate chamber to 25°C and shut it down after 2 hours ; at the same time, Set the walk-in chamber temperature to 25°C and shut it down after 4 hours	
29	Turn off the data-acquisition and control system after the temperature and pressure become stable	
30	Backup test data	

Totally, 31 hours are needed, which equals to about four working days.

Definition of the cold orbit heater auto control mode: when the pump inlet temperature is lower than -30°C, turn on the cold orbit heater, then when the pump inlet temperature is higher than -25°C, turn off the cold orbit heater.



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Table 9-1 Cold plate temperature data for nominal operation

Time (min)	RamNormal (°C)	WakeNormal (°C)
0	-15.0	-17.5
3.75	-13.7	-16.5
7.5	-12.5	-15.7
11.25	-11.5	-15.2
15	-10.7	-15.0
18.75	-10.2	-15.2
22.5	-10.0	-15.7
26.25	-10.2	-16.5
30	-10.7	-17.5
33.75	-11.5	-18.7
37.5	-12.5	-20.0
41.25	-13.7	-21.3
45	-15.0	-22.5
48.75	-16.3	-23.5
52.5	-17.5	-24.3
56.25	-18.5	-24.8
60	-19.3	-25.0
63.75	-19.8	-24.8
67.5	-20.0	-24.3
71.25	-19.8	-23.5
75	-19.3	-22.5
78.75	-18.5	-21.3
82.5	-17.5	-20.0
86.25	-16.3	-18.7
90	-15.0	-17.5

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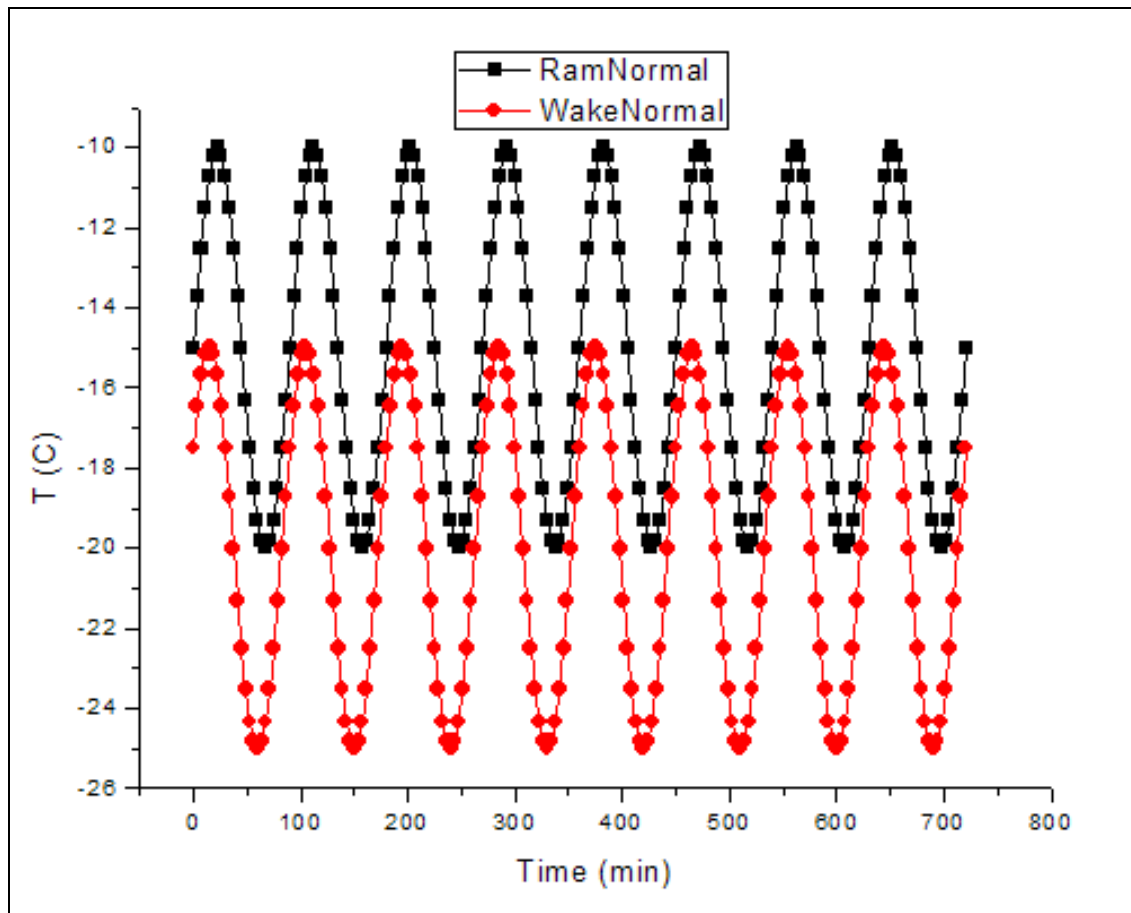



Figure 9-1 Cold plate temperature profiles for nominal operation


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9.3 Extreme orbit operation conditions test


The following procedure should be carried out during extreme orbit operation conditions test.

1) Hottest orbit /Hottest orbit +5K


Step	Action	Req. Verification
1	Record the ambient temperature, atmospheric pressure and humidity of the cleaning room	
2	Turn on the data-acquisition and control system.	
3	<ul style="list-style-type: none"> ● Run the walk-in climate chamber at 15°C ● Run the bench-top climate chamber at the lowest value (-10°C) of the hottest orbit temperature profiles. 	
4	Run the cold plates with set temperature profile of the hottest orbit (as shown in Figure 9.2 TBC) (the temperature profile must be calibrated based on the heat leak test data, to allow the pump inlet temperature as close to that of the SINDA/Fluint simulation value as possible)	
5	Start USS temperature control and set USS temperature to the hottest orbit case (=25°C) until it becomes steady	
6	Start accumulator temperature control (heater/TEC control) and set the accumulator temperature to 20°C, at least 5°C above the temperature of pump inlet	
7	Start the pump control and run the pump at 7500rpm after the subcooling of 5°C is achieved	
8	Set the cold orbit heater control to the auto mode	
9	Change the accumulator temperature to Tset=15°C (make sure the subcooling is achieved during this process)	

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10	Switch on the pre-heaters of 8W*2	
11	Turn on the Tracker heat load of 144W (72W for each ring) and run the loop for 3 hours (two cycles)	
12	Check the pressure drop at different pump speeds (3000, 5000, 7500, 10000rpm)	LP-06, LP-13
	1. Change the pump speed to 3000rpm and record the pressure drop for one cycle (1.5 hour) 2. Change the pump speed from 3000 to 5000rpm and record the pressure drop for 10 minutes 3. Change the pump speed from 5000 to 7500rpm and record the pressure drop for 10 minutes 4. Change the pump speed from 7500 to 10000rpm and record the pressure drop for 10 minutes 5. Change the pump speed to 7500rpm and run the loop for 10 minutes	Note: to keep the rotation speed is not necessary to keep the mass flow rate It takes a risk of bubbling at low mass flow rate
13	Switch on/off star tracker simulator and check evaporator temperature stability (1.5 hours)	LP-01
14	Heater imbalance test (50% imbalance between upper and lower tracker rings) $(P_{up}-P_{down})/(P_{up}+P_{down})=50\%$ (6 hours)	LP-16
	1. Increase the heat load to top evaporator to 108W and decrease the heat load to bottom evaporator to 36W gradually until 50% imbalance is obtained otherwise the temperature of the evaporator loses its required uniformity and then run the loop for 3 hours 2. Decrease the heat load to top evaporator to 36W and increase the heat load to bottom evaporator to 108W gradually until 50% imbalance is obtained otherwise the temperature of the evaporator loses its required uniformity and then run the loop for 3 hours	
15	Change the heat load back to 72W for each ring and run the loop for 1.5 hours	
16	Switch on/off star tracker simulator and check evaporator temperature stability (1.5 hours)	LP-01
	1. Switch on star tracker simulator of 6.8W and run the loop for 20 minutes 2. Switch off star tracker simulator and run the loop for 20 minutes 3. Repeat step 1 and 2 twice	

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17	Switch on/off the start up heater and check evaporator temperature stability (1.5 hours)	LP-01
	1. Switch on start up heater of 50W and run the loop for 20 minutes 2. Switch off start up heater and run the loop for 20 minutes 3. Repeat step 1 and twice	
18	Switch on/off the cold orbit heater and check evaporator temperature stability (1.5 hours)	LP-01
	1. Change the cold orbit heater to manual mode and switch on cold orbit heater of 60W and run the loop for 20 minutes 2. Switch off the cold orbit heater and run the loop for 20 minutes 3. Repeat step 1 and 2 twice 4. Switch the cold orbit heater control to auto mode	
19	Loop stability and responses check to the rapid change of condenser temperature	LP-15
	1. Set a temperature profile to the cold plates with maximum temperature change rates of both positive (heating) and negative (cooling) 2. Check the loop responses and stability	
20	Turn off the Tracker heat load	
21	Turn off the pre-heaters	
22	Turn off the pump	
23	Turn off the accumulator temperature control	
24	Shut down the cold orbit heater control	
25	Change the bench-top climate chamber temperature to the lowest value (-5°C) of the hottest orbit +5K temperature profile	
26	Change the cold plate temperature profiles (as shown in figure 9.2) to hottest orbit +5K case (as shown in figure 9.3) (closest to critical point operation)	

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27	Change the USS temperature to hottest orbit +5K case (=30°C) until it is steady	
28	Start the accumulator temperature control and set the accumulator temperature to 20 to 25°C, at least 5°C higher than that of pump inlet	
29	Start the pump control and run the pump at 7500rpm after the subcooling of 5°C is achieved	
30	Change the accumulator temperature to Tset =15°C,(make sure the subcooling of 5°C is achieved during this process)	
31	Switch on the pre-heaters	
32	Set the cold orbit heater control to the auto mode	
33	Turn on the heat load of 144W (72W for each ring) and run the loop for 3 hours (two cycles) Keep monitoring the subcooling, if it is smaller than 5°C, increase the Tset to 20°C, if there is not enough subcooling, stop the test.	
34	Heater imbalance test (50% imbalance between upper and lower tracker rings) $(P_{up}-P_{down})/(P_{up}+P_{down})=50\%$ (6 hours)	LP-16
	1. Increase the heat load to top evaporator to 108W and decrease the heat load to bottom evaporator to 36W gradually until 50% imbalance is obtained otherwise the temperature of the evaporator loses its required uniformity and then run the loop for 3 hours 2. Decrease the heat load to top evaporator to 36W and increase the heat load to bottom evaporator to 108W gradually until 50% imbalance is obtained otherwise the temperature of the evaporator loses its required uniformity and then run the loop for 3 hours	
35	Change the heat load back to 72W for each ring and run the loop for 1.5 hours	
36	Turn off the Tracker heat load simulators	
37	Turn off the pre-heaters	
38	Turn off the pump	
39	Shut down the accumulator temperature control	

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40	Shut down the USS temperature control	
41	Shut down the cold orbit heater control	
42	Turn off the cold plates temperature control	
43	Set the bench-top climate chamber to 25°C and shut it down after 2 hours ; at the same time, Set the walk-in chamber temperature to 25°C and shut it down after 4 hours	
44	Turn off the data-acquisition and control system after the temperature and pressure become stable	
45	Backup test data	

- Note, the start-up and shut-down sequences are different for hot case and cold case. It depends on the subcooling (especially in hot cases) to avoid bubbling, and the evaporator inlet temperature (especially in the cold cases) to avoid damaging the tracker. During the Strat-up and Shut-down processes, one must pay great attention to these issues to verify the right sequences.
- Subcooling criteria is determined in this way: set the cold plate at the highest temperature of the T profile to get the pump inlet subcooling close to but larger than 5°C, switch the cold orbit heater to manual control mode and turn on the cold orbit heater; as the subcooling becomes smaller, detect bubble formation through the pump.



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Table 9-2 Cold plate temperature data for hottest orbit test and hottest orbit +5K margin test

Time (min)	RamHot (°C)	WakeHot (°C)	RamHotMargin (°C)	WakeHotMargin (°C)
0	10.0	-7.1	15.0	-2.1
3.75	12.0	-6.2	17.0	-1.2
7.5	13.7	-4.7	18.7	0.3
11.25	15.1	-2.9	20.1	2.1
15	15.9	-0.9	20.9	4.1
18.75	16.2	1.0	21.2	6.0
22.5	16.2	2.9	21.2	7.9
26.25	15.7	4.6	20.7	9.6
30	14.9	5.9	19.9	10.9
33.75	13.8	6.8	18.8	11.8
37.5	12.5	7.3	17.5	12.3
41.25	10.9	7.3	15.9	12.3
45	9.2	6.7	14.2	11.7
48.75	7.6	5.3	12.6	10.3
52.5	6.3	3.3	11.3	8.3
56.25	5.4	1.2	10.4	6.2
60	4.7	-0.6	9.7	4.4
63.75	3.1	-2.4	8.1	2.6
67.5	0.7	-3.9	5.7	1.1
71.25	-0.4	-5.4	4.6	-0.4
75	0.8	-6.5	5.8	-1.5
78.75	3.0	-7.2	8.0	-2.2
82.5	5.4	-7.5	10.4	-2.5
86.25	7.8	-7.5	12.8	-2.5
90	10.0	-7.1	15.0	-2.1

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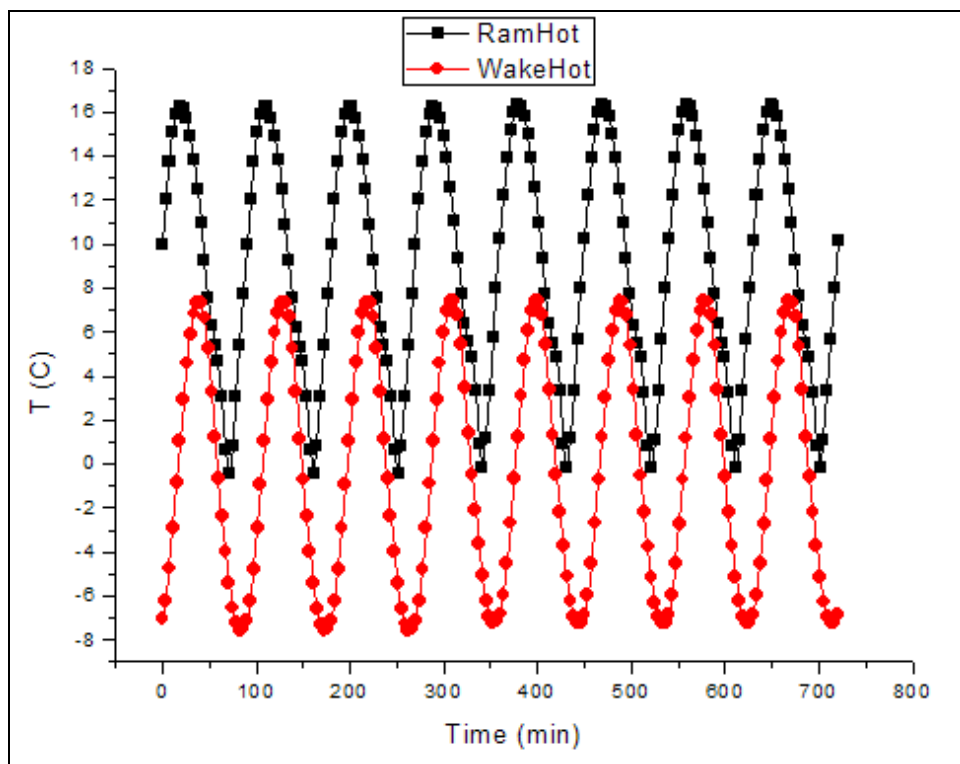


Figure 9-2 Cold plate temperature profile for hottest orbit test

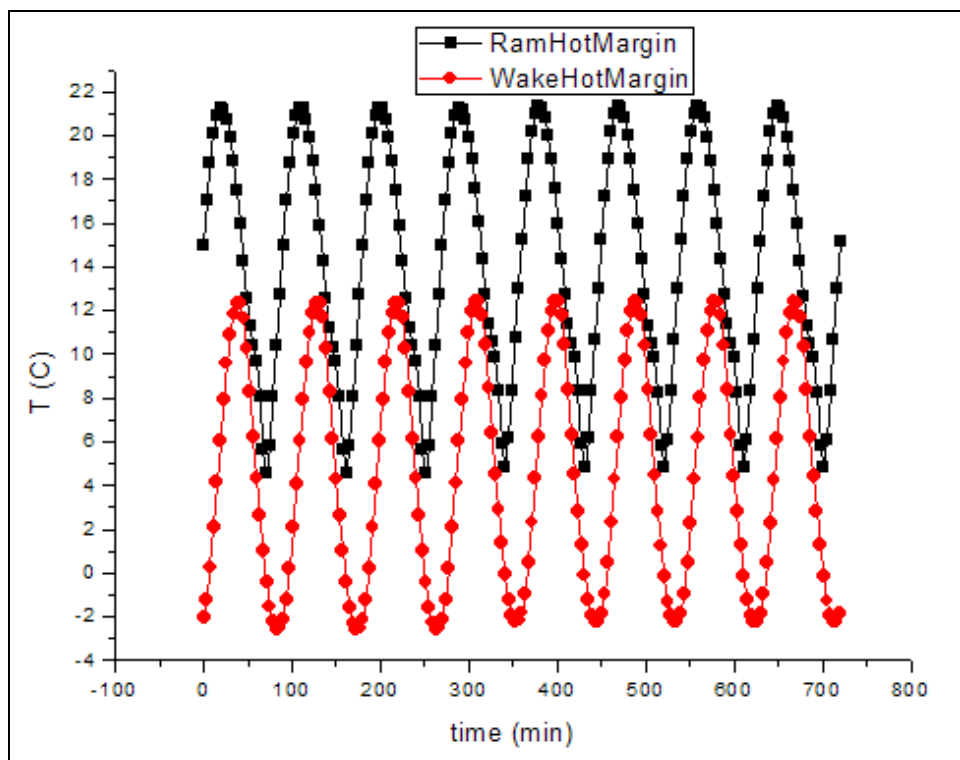




Figure 9-3 Cold plate temperature profile for hottest orbit +5K margin test


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2) Coldest orbit/ Coldest orbit -11K


Step	Action	Req. Verification
1	Record the ambient temperature, atmospheric pressure and humidity of the cleaning room	
2	Turn on the data-acquisition and control system.	
3	<ul style="list-style-type: none"> ● Run the walk-in climate chamber at -15°C ● Run the bench-top climate chamber at the lowest value (-40°C) of the coldest orbit temperature profiles 	
4	Run the cold plates with set temperature profile of the coldest orbit (as shown in figure 9.4). * the temperature profile must be calibrated based on the heat leak test data, to allow the pump inlet temperature as close to that of the SINDA/Fluint simulation value as possible.	
5	Start the USS temperature control and set the USS temperature at the coldest orbit case (=-5°C)	
6	Start accumulator temperature control (heater/TEC control) and set the accumulator temperature at -10°C, at least 5°C about the temperature of pump inlet	
7	Start the pump control and run pump at 3000rpm after the subcooling of 5°C is achieved	
8	Switch on the pre-heater	
9	Start the cold orbit heater manual control mode	
10	Check the pump inlet temperature, the evaporator inlet temperature and the out temperature	
11	If any of the evaporator inlet temperature is lower than -20°C, switch on the start-up heater, else, set the pump to 5000rpm;	
12	Check the pump inlet temperature, the evaporator inlet temperature and the out temperature	
13	If any of the evaporator inlet temperature is lower than -20°C and the start-up heater is off, switch on the start-up	

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	heater; set the pump to 5000rpm;	
14	If any of the evaporator inlet temperature is still lower than -20°C and the cold orbit heater is off, switch on the cold orbit heater; else, set the pump to 5000rpm;	
15	Change the accumulator temperature to Tset=-15°C (make sure the subcooling is achieved during this process)	
16	Check if the CO2 is in two phase in both of the evaporators by monitoring the inlet and outlet temperature to see if the overheating has occurred	
17	Turn on the Tracker heat load of 144W (72W for each ring)	
18	Turn off the start-up heater if it is on,	
19	Switch the cold orbit heater control from manual to auto mode, and run the loop for 3 hours	
20	Check the pressure drop at different pump speeds (3000, 5000, 7500, 10000rpm)	LP-06, LP-13
	1. Set the pump speed to 3000rpm and record the pressure drop for 1.5 hour 2. Change the pump speed from 3000 to 5000rpm and record the pressure drop for 10 minutes 3. Change the pump speed from 5000 to 7500rpm and record the pressure drop for 10 minutes 4. Change the pump speed from 7500 to 10000rpm and record the pressure drop for 10 minutes 5. Change the pump speed to 5000rpm (0.5 hour).	
21	Heater imbalance test (50% imbalance between upper and lower tracker rings) $(P_{up}-P_{down})/(P_{up}+P_{down})=50\%$ (6 hours)	LP-16
	1. Increase the heat load to top evaporator to 108W and decrease the heat load to bottom evaporator to 36W gradually until 50% imbalance is obtained otherwise the temperature of the evaporator loses its required uniformity 2. Decrease the heat load to top evaporator to 36W and increase the heat load to bottom evaporator the 108W gradually until 50% imbalance is obtained otherwise the temperature of the evaporator loses its required uniformity and then run the loop for 3 hours	
22	Change the heat load back to 72W for each ring and run the loop for 1.5 hours	

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23	Switch on/off the start-up heater and check the evaporator temperature stability (1.5 hours)	LP-01
	1. Switch on the start-up heater of 50W and run the loop for 20 minutes 2. Switch off the start-up heater and run the loop for 20 minutes 3. Repeat step 1 and 2 twice	
24	Loop stability and responses check to the rapid change of condenser temperature	LP-15
	1. Set a temperature profile to the cold plates with maximum temperature change rates of both positive (heating) and negative (cooling) 2. Check the loop responses and stability	
25	Turn off the Tracker heat load simulators	
26	Turn off the pre-heater	
27	Turn off the pump	
28	Turn off the accumulator temperature control	
29	Turn off the cold orbit heater control	
30	Change the bench-top climate chamber temperature to the lowest value (-51°C) of the coldest -11K orbit temperature profiles (Figure 9.5)	
31	Change cold plate temperature profiles (as shown in figure 9.5 TBC) to coldest orbit -11K	
32	Change the USS temperature profile to hottest orbit -11K case (= -10°C)	
33	Start accumulator temperature control and set the accumulator temperature at -10°C, at least 5°C larger than the temperature of pump inlet	
34	Start the pump control and run pump at run the pump at 3000rpm after the subcooling of 5°C is achieved	
35	Switch on the pre-heater	

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36	Start the cold orbit heater manual control mode	
37	Check the pump inlet temperature and the evaporator inlet temperature	
38	If any of the evaporator inlet temperature is lower than -20°C, switch on the start-up heater, else, set the pump to 5000rpm;	
39	Check the pump inlet temperature and the evaporator inlet temperature	
40	If any of the evaporator inlet temperature is lower than -20°C and the start-up heater is off, switch on the start-up heater; else, set the pump to 5000rpm;	
41	If any of the evaporator inlet temperature is still lower than -20°C and the cold orbit heater is off, switch on the cold orbit heater; else, set the pump to 5000rpm;	
42	Change the accumulator temperature to Tset=-15°C (make sure the subcooling is achieved during this process)	
43	Check if the CO ₂ is in two phase in both of the evaporators by monitoring the inlet and outlet temperature to see if the overheating has occurred	
44	Turn on the Tracker heat load of 144W (72W for each ring)	
45	Switch the cold orbit heater control from manual to auto mode, and run the loop for 3 hours	
46	Check the pressure drop at different pump speeds (3000, 5000, 7500, 10000rpm)	LP-06, LP-13
	1. Set the pump speed to 3000rpm and record the pressure drop for one cycle (1.5 hours) 2. Change the pump speed from 3000 to 5000rpm and record the pressure drop for 10 minutes 3. Change the pump speed from 5000 to 7500rpm and record the pressure drop for 10 minutes 4. Change the pump speed from 7500 to 10000rpm and record the pressure drop for 10 minutes 5. Change the pump speed to 5000rpm (0.5 hours)	
47	Heater imbalance test (50% imbalance between upper and lower tracker rings) $(P_{up}-P_{down})/(P_{up}+P_{down})=50\%$ (6 hours)	LP-16
	1. Increase the heat load to the top evaporator to 108W and decrease the heat load to the bottom evaporator to	

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	36W gradually until 50% imbalance is obtained otherwise the temperature of the evaporator loses its required uniformity and then run the loop for 3 hours 2. Decrease the heat load to the top evaporator to 36W and increase the heat load to the bottom evaporator to 108W gradually until 50% imbalance is obtained otherwise the temperature of the evaporator loses its required uniformity and then run the loop for 3 hours	
48	Change the heat load back to 72W for each ring and run the loop for 1.5 hours	
49	Turn off the tracker heat load simulators	
50	Turn off the pump when the evaporator temperature start to decrease	
51	Turn off the pre-heater	
52	Shut down the cold orbit heater control	
53	Shut down the accumulator temperature control	
54	Shut down the USS temperature control	
55	Turn off the cold plates temperature control	
56	Set the bench-top climate chamber to 25°C and shut it down after 2 hours ; at the same time, Set the walk-in chamber temperature to 25°C and shut it down after 4 hours	
57	Turn off the data-acquisition and control system after the temperature and pressure become stable	
58	Backup test data into another PC	
	Turn to set point temperature change test (from step 45)	Option B



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Table 9-3 Cold plate temperature data for coldest orbit test and coldest **orbit -5 K** margin test

Time(min)	RamCold (°C)	WakeCold (°C)	RamColdMargin (°C)	WakeColdMargin (°C)
0	-40.0	-28.7	-51.0	-39.7
3.75	-39.7	-29.0	-50.7	-40.0
7.5	-39.3	-28.9	-50.3	-39.9
11.25	-38.7	-28.2	-49.7	-39.2
15	-37.6	-26.8	-48.6	-37.8
18.75	-36.5	-25.1	-47.5	-36.1
22.5	-35.7	-23.1	-46.7	-34.1
26.25	-35.1	-21.2	-46.1	-32.2
30	-34.5	-19.5	-45.5	-30.5
33.75	-35.7	-19.1	-46.7	-30.1
37.5	-36.5	-18.8	-47.5	-29.8
41.25	-37.0	-18.5	-48.0	-29.5
45	-37.6	-18.5	-48.6	-29.5
48.75	-38.3	-19.0	-49.3	-30.0
52.5	-39.3	-20.2	-50.3	-31.2
56.25	-40.3	-21.8	-51.3	-32.8
60	-40.3	-22.9	-51.3	-33.9
63.75	-39.8	-23.2	-50.8	-34.2
67.5	-39.9	-24.1	-50.9	-35.1
71.25	-40.1	-24.9	-51.1	-35.9
75	-40.2	-25.8	-51.2	-36.8
78.75	-40.2	-26.6	-51.2	-37.6
82.5	-40.2	-27.4	-51.2	-38.4
86.25	-40.2	-28.2	-51.2	-39.2
90	-40.0	-28.8	-51.0	-39.8

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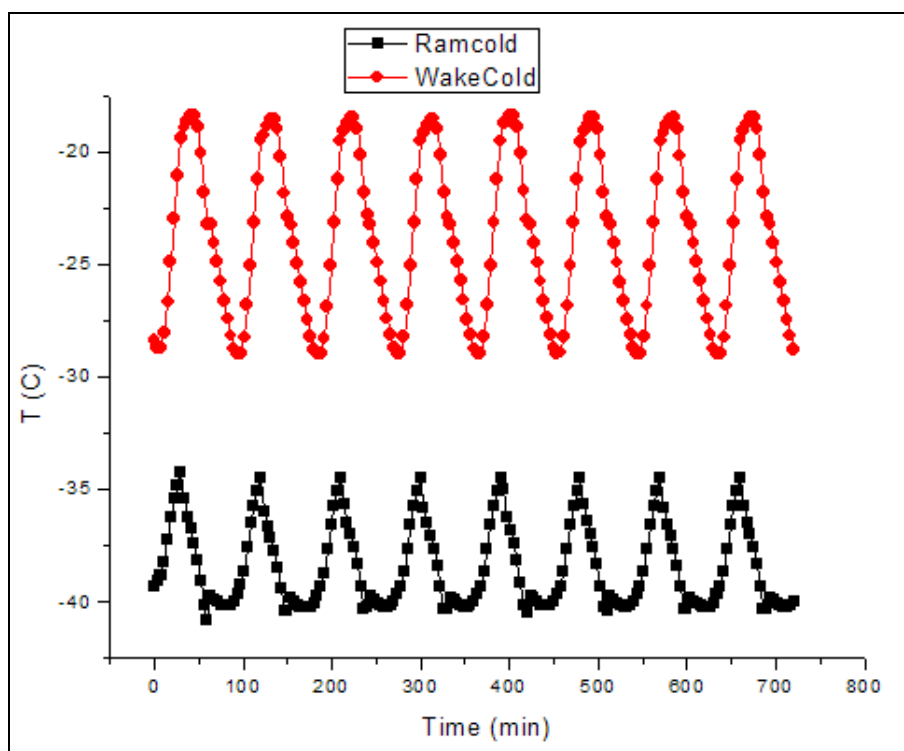


Figure 9-4 Cold plate temperature profile for coldest orbit test

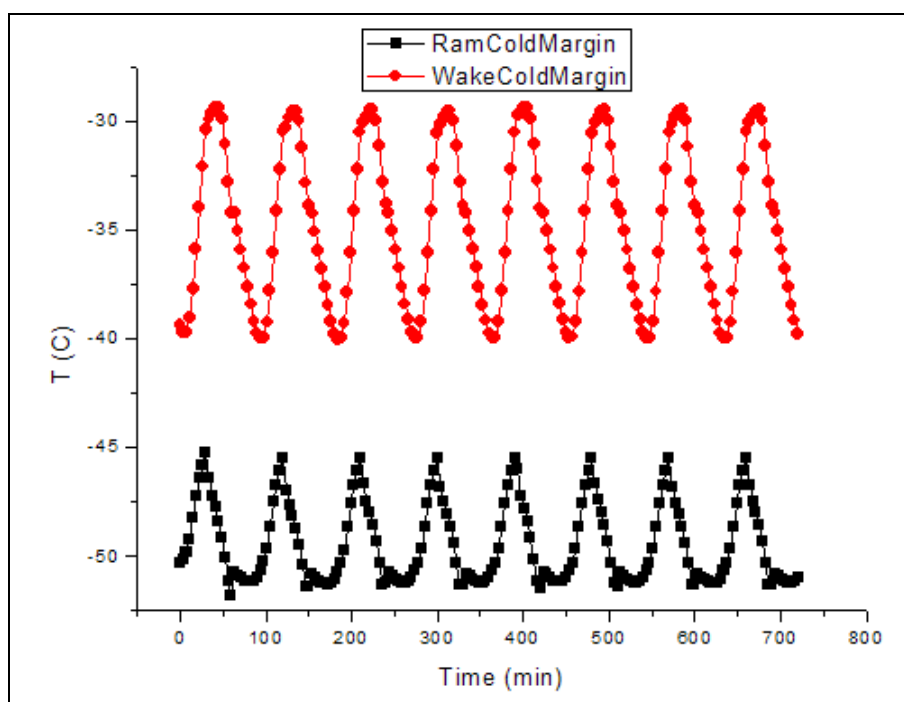




Figure 9-5 Cold plate temperature profile for coldest orbit -11K margin test

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9.4 Set-point change test

The following procedure should be carried out when set-point change test is performed.


Step	Action	Req. verification
1	Record the ambient temperature, atmospheric pressure and humidity of the cleaning room	
2	Turn on the data-acquisition and control system.	
3	Run the walk-in climate chamber at -15°C Run bench-top climate chamber at the lowest value (=-40°C) of the coldest orbit temperature profiles	
4	Run the cold plates with set temperature profile of the coldest orbit, as shown in Figure 9.4.	
5	Start USS temperature control and set USS temperature at the coldest orbit case (=-5°C)	
6	Repeat start-up procedure in cold case	
7	Turn off the start-up heater and run the loop for 3 hours	
8	Change the walk-in climate chamber temperature to 0°C Change bench-top climate chamber to the lowest value (=-30°C) of the moderate orbit temperature profiles	(continue from cold orbit test option B)
9	Change the cold plate temperature profiles to the nominal operation, as shown in Figure 9-1; and change USS	

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	temperature to the nominal case (=5°C)	
10	Based on the observation of subcooling variation, select a time to Increase the accumulator temperature from Tset=-15 to Tset=0°C	
11	Check Tset=0°C	
12	Check the stability of the temperature and pressure of the loop	
13	<ul style="list-style-type: none"> ● Change the walk-in climate chamber temperature to 15°C ● Change bench-top climate chamber to the lowest value (= -10°C) of hottest orbit temperature profiles 	
14	Change the cold plate temperature profiles to hottest orbit case, as shown in Figure 9-2; and change USS temperature to the hottest case (=25°C)	
15	Increase the accumulator temperature from Tset=0 to Tset=15□	
16	Check Tset=15□	
17	Check the stability of the temperature and pressure of the loop	
18	<ul style="list-style-type: none"> ● Change the walk-in climate chamber temperature to 0°C ● Change bench-top climate chamber to the lowest value (= -30°C) of moderate orbit temperature profiles 	
19	Change the cold plate temperature profiles to the nominal operation case, as shown in Figure 9-1; and change USS temperature to the nominal case (=5°C)	
20	Decrease the accumulator temperature from Tset=15 to Tset=0°C	
21	Check Tset=0°C	


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22	Check the stability of the temperature and pressure of the loop	
23	<ul style="list-style-type: none"> ● Change the walk-in climate chamber temperature to -15°C ● Change bench-top climate chamber to the lowest value of coldest orbit temperature profiles 	
24	Change the cold plate temperature profiles to coldest orbit case, as shown in Figure 9-4; and change USS temperature to the hottest case (=25°C)	
25	Decrease the accumulator temperature from Tset=0 to Tset=-15□	
26	Check the pump inlet temperature	
27	Start cold orbit heater control and turn it on when pump inlet temperature is less than -25°C	
28	Turn off the heat load	
29	Turn off the pre-heater	
30	Turn off the cold orbit heater control	
31	Turn off pump	
32	Turn off accumulator temperature control	
33	Turn off cold plate temperature control	
34	Set the bench-top climate chamber to 25°C and shut it down after 2 hours	
35	Set the walk-in chamber temperature to 25°C and shut it down after 4 hours	
36	Turn off the data-acquisition and control system	
37	Backup test data into another PC	

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9.5 Supercritical pump start up

Step	Action
1	Record the ambient temperature, atmospheric pressure and humidity of the cleaning room
2	Turn on the data-acquisition and control system.
3	<ul style="list-style-type: none"> ● Run the walk-in climate chamber at -15°C ● Run bench-top climate chamber at -40°C
4	Run the cold plates with set temperature profile of the hottest orbit (as shown in Figure 9-2) (the temperature profile must be calibrated based on the heat leak data, to allow the pump inlet temperature as close to that of the SINDA/Fluint simulation value as possible)
5	Start USS temperature control and set USS temperature to the hottest orbit case (=35°C) until it becomes steady
6	Start the start-up radiator simulator temperature control and set start-up radiator simulator temperature to the 35°C until it becomes steady
7	Check the pump temperature $\geq 33^{\circ}\text{C}$
8	Turn off the start-up radiator simulator temperature control
9	Start the pump control and run the pump at 3000rpm
10	Check the changes of the temperatures along the loop to make sure that CO2 flow through the pump, otherwise change the pump speed to 5000rpm
11	Check the changes of the temperatures along the loop to make sure that CO2 flow through the pump, otherwise change the pump speed to 7500rpm


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12	Check the changes of the temperatures along the loop to make sure that CO2 flow through the pump, otherwise change the pump speed to 10000rpm
13	Check the changes of the temperatures along the loop to make sure that CO2 flow through the pump, otherwise turn off the pump
14	Check the temperature of the pump inlet $\leq 15^{\circ}\text{C}$
15	Turn off the pump
16	Shut down the USS temperature control
17	Turn off the cold plates temperature control
18	Set the bench-top climate chamber to 25°C and shut it down after 2 hours; at the same time, set the walk-in chamber temperature to 25°C and shut it down after 4 hours
19	Turn off the data acquisition and control system after the temperature and pressure become stable
20	Backup test data into to another PC

9.6 RC responses to the heaters (with $Fr=0\text{g/s}$)


When the loop is stable at one of the three set-point temperature

1. turn on the start up heater, and record the its temperature response until steady or reach 60°C , then turn off the start up heater
2. turn on the cold orbit heater, and record the its temperature response until steady or reach 60°C , then turn off the cold orbit heater
3. turn on any of the pre-heater, and record the its temperature response until steady or reach 60°C , then turn off the pre-heater, and check the other

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pre-heater


4. turn on the star tracker heater, and record the its temperature response until steady or reach 60°C, then turn off the star tracker heater

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10. TEST SHEET


10.1 Nominal operation condition test

TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:		QA:				
Step No.	Action and Description			Comments	Req.	Time
	START-UP					
1.	Record environment conditions					
	Temperature: °C	Humidity: %RH	Pressure: mbar			
2	Check T and P sensors					
	T sensors:		P sensors:			
3	Check heaters/TEC					
	Pre-heater:	Cold orbit heater:	Accumulator Heater:			
	Top: Ω	Ram : Ω	Operation heater: Ω			
	Bottom: Ω	Wake: Ω	Emergency heater: Ω			
	Start-up heater: Ω	Liquid line health heater: Ω	TEC: Ω			
4	Turn on the data-acquisition and control system					
5.	Run climate chambers					


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
	Walk-in Chamber:		Bench-top Chamber:			
6.	Run cold plates (temperature profile document No.)					
	Ram temperature profile:		Wake temperature profile:			
7.	Start USS temperature control and run USS					
	USS temperature profile(or profile document):					
8.	Start Accumulator T control				LP-22	
	Tset: °C	Max heating power: W	Max cooling power: W			
	APS(bar)				LP-28	
9.	Check the subcooling: ΔT= °C				5□	
10.	Start the cold orbit heater auto control mode				LP-25	
11.	Start pump control and run pump at 5000rpm				LP-26, LP-29, PW-1	
	Voltage: V	Current: A	DPS: mbar			
12.	Change the accumulator temperature to Tset=0□				LP-22, PW-06	
	Tset: °C	Max heating power: W	Max cooling power: W			
13.	Switch on the pre-heaters				LP-23, PW-02	
	Top: V* A= W	Bottom: V* A= W		Notice two phase CO2 flow into the evaporators	8W for each Pre-heater	


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Test engineer:		QA:				
Step No.	Action and Description			Comments	Req.	Time
	TEST PART					
14.	Turn on the heat load of 144W (and run the loop for 3 hours)					
	Top : Inner ring: V* A= W Outer: ring: V* A= W total: W		Bottom : Inner ring: V* A= W Outer: ring: V* A= W total: W			
	Vary heat load and check evaporator temperature stability				LP-01, LP-02	
15.	Change the heat load to 220W (and run the loop for 3 hours)					
	Top : Inner ring: V* A= W Outer: ring: V* A= W total: W		Bottom : Inner ring: V* A= W Outer: ring: V* A= W total: W			
16.	Change the heat load to100W (and run the loop for 1.5 hours)					
	Top : Inner ring: V* A= W Outer: ring: V* A= W total: W		Bottom : Inner ring: V* A= W Outer: ring: V* A= W total: W			
17.	Change the heat load to144W (and run the loop for 1.5 hours)				72W for each ring	
	Top : Inner ring: V* A= W		Bottom : Inner ring: V* A= W			

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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:		QA:				
Step No.	Action and Description			Comments	Req.	Time
	Outer: ring: V* A= W total: W	Outer: ring: V* A= W total: W				
<i>Check the pressure drop at different pump speeds (3000, 5000, 7500, 10000rpm)</i>					LP-13, LP-06, PW-01, LP-28	
18.	Change the pump speed to 3000rpm (and run the loop for 1.5 hours)					
	ΔPloop: mbar	DPS:				

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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:			
Test engineer:			QA:				
Step No.	Action and Description			Comments		Req.	Time
	Inner ring: V* A= W	Inner ring: V* A= W					
	Outer: ring: V* A= W	Outer: ring: V* A= W					
	total: W	total: W					
24.	Change the heat load to Top Evaporator to 36Wand Bottom Evaporator to 108W (and run the loop for 3 hours)						
	Top: Inner ring: V* A= W	Bottom: Inner ring: V* A= W					
	Outer: ring: V* A= W	Outer: ring: V* A= W					
	total: W	total: W					
25.	Change the heat load to 72W for each evaporator (and run the loop for 1.5 hours)						
	Top: Inner ring: V* A= W	Bottom: Inner ring: V* A= W					
	Outer: ring: V* A= W	Outer: ring: V* A= W					
	total: W	total: W					
Switch on/off star tracker simulator and check evaporator temperature stability						LP-01, LP-02	
26.	Switch on star tracker simulator and run the loop for 20 minutes)						
	Voltage of star tracker heater: V	Current of star tracker heater: A					
27.	Switch off star tracker simulator and run the loop for 20 minutes)						
28.	Switch on star tracker simulator and run the loop for 20 minutes)						
	Voltage of star tracker heater: V	Current of star tracker heater: A					
	Switch off star tracker simulator and run the loop for 20 minutes)						

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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:	
Test engineer:			QA:		
Step No.	Action and Description		Comments	Req.	Time
29.	Switch on star tracker simulator and run the loop for 20 minutes)				
	Voltage of star tracker heater:	V	Current of star tracker heater:	A	
	Switch off star tracker simulator and run the loop for 20 minutes)				
Switch on/off cold orbit heater and check evaporator temperature stability				LP-01, LP-02, PW-03	
30.	Change the cold orbit heater control mode to manual and switch on cold orbit heater (and run the loop for 20 minutes)				
	Voltage of cold orbit heater:	V	Current of cold orbit heater:	A	
31.	Switch off the cold orbit heater (and run the loop for 20 minutes)				
32.	Switch on the cold orbit heater (and run the loop for 20 minutes)				
	Voltage of cold orbit heater:	V	Current of cold orbit heater:	A	
33.	Switch off the cold orbit heater (and run the loop for 20 minutes)				
34.	Switch on the cold orbit heater (and run the loop for 20 minutes)				
	Voltage of cold orbit heater:	V	Current of cold orbit heater:	A	
35.	Switch off the cold orbit heater				
36.	Change the cold orbit heater control mode to auto (and run the loop for 20 minutes)				
Switch on/off start-up heater and check evaporator temperature stability				LP-01, LP-02, PW-04	
37.	Switch on the start-up heater (and run the loop for 20 minutes)				
	Voltage of start-up heater:	V	Current of start-up heater:	A	
38.	Switch off the start-up heater (and run the loop for 20 minutes)				

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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST			TEST DATE:		
Test engineer:		QA:			
Step No.	Action and Description		Comments	Req.	Time
39.	Switch on the start-up heater (and run the loop for 20 minutes)				
	Voltage of start-up heater: V	Current of start-up heater: A			
40.	Switch off the start-up heater (and run the loop for 20 minutes)				
41.	Switch on the start-up heater (and run the loop for 20 minutes)				
	Voltage of start-up heater: V	Current of start-up heater: A			
42.	Switch off the start-up heater (and run the loop for 20 minutes)				
Loop stability and responses check to the rapid change of condenser temperature				LP-15	
43.	Increase the cold plates temperature				
	Ram T increasing rate: K/s	Wake T increasing rate: K/s			
44.	Decrease the cold plates temperature				
	Ram T decreasing rate: K/s	Wake T decreasing rate: K/s			
	SHUT DOWN THE LOOP				
45.	Turn off the tracker heater load				
46.	Turn off pre-heaters				
47.	Shutdown pump				
48.	Turn off accumulator T control				
49.	Shut down the cold orbit heater control				
50.	Turn off USS T control				
51.	Turn off the cold plates T control				
52.	Set the bench-top climate chamber to 25°C (and run it for 2 hours)				


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:	
Test engineer:		QA:			
Step No.	Action and Description		Comments	Req.	Time
	Set-point of the bench-top climate chamber	°C			
53.	Set the walk-in chamber temperature to 25°C (and run it for 2 hours)				
	Set-point of the walk-in climate chamber	°C			
54.	Shut down the bench-top climate chamber				
55.	Shut down the walk-in climate chamber				
56.	Turn off the data-acquisition and control system				
57.	Backup test data				

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10.2 Hottest orbit/hottest orbit +5K

TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:		QA:				
Step No.	Action and Description			Comments	Req.	Time
	START-UP					
1.	Record environment conditions					
	Temperature: °C	Humidity: %RH	Pressure: mbar			
2	Check T and P sensors					
	T sensors:		P sensors:			
3	Check heaters/TEC					
	Pre-heater:	Cold orbit heater:	Accumulator Heater:			
	Top: Ω	Ram : Ω	Operation heater: Ω			
	Bottom: Ω	Wake: Ω	Emergency heater: Ω			
	Start-up heater: Ω	Liquid line health heater: Ω	TEC: Ω			
4	Turn on the data-acquisition and control system					
5.	Run climate chambers					
	Walk-in Chamber:		Bench-top Chamber:			


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
6.	Run cold plates (temperature profile document No.)					
	Ram temperature profile:		Wake temperature profile:			
7.	Start USS temperature control and run USS					
	USS temperature profile(or profile document):					
8.	Start accumulator T control				LP-22, PW-06	
	Tset: <input type="checkbox"/>	Max heating power: W	Max cooling power: W			
9.	Check the subcooling: ΔT= <input type="checkbox"/>					
10.	Start pump control and run pump at 7500rpm				LP-26, PW-01	
	Voltage: V	Current: A	DPS: mbar			
11.	Set the cold orbit heater control to the auto mode					
12.	Change the accumulator temperature to Tset=15 <input type="checkbox"/>					
	Tset: <input type="checkbox"/>	Max heating power: W	Max cooling power: W			
13.	Switch on the pre-heaters (8W*2)					
	Top: V* A= W		Bottom: V* A= W		Notice two phase CO2 flow into the evaporators	
	TEST PART					
14.	Turn on the heat load of 72W for each evaporator (and run the loop for 3 hours)					
	Top :		Bottom :			


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
	Inner ring: V* A= W	Inner ring: V* A= W				
	Outer: ring: V* A= W	Outer: ring: V* A= W				
	total: W	total: W				
	Vary heat load and check evaporator temperature stability				LP-01, LP-02	
Check the pressure drop at different pump speeds (3000, 5000, 7500, 10000rpm)					LP-13, LP-06	
15.	Change the pump speed to 3000rpm (and run the loop for 1.5 hours)					
	ΔPloop: mbar	DPS: mbar				
16.	Change the pump speed to 5000rpm (and run the loop for 10 minutes)					
	ΔPloop: mbar	DPS: mbar				
17.	Change the pump speed to 7500rpm (and run the loop for 10 minutes)					
	ΔPloop: mbar	DPS: mbar				
18.	Change the pump speed to 10000rpm (and run the loop for 10 minutes)					
	ΔPloop: mbar	DPS: mbar				
19.	Change the pump speed to 7500rpm (and run the loop for 10 minutes)					
	ΔPloop: mbar	DPS: mbar				
Heater imbalance test					LP-16	
20.	Change the heat load to Top Evaporator to 108W and Bottom Evaporator to 36W (and run the loop for 3 hours)					

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Test engineer:			QA:		
Step No.	Action and Description		Comments	Req.	Time
	Top: Inner ring: V* A= W Outer: ring: V* A= W total: W	Bottom: Inner ring: V* A= W Outer: ring: V* A= W total: W			
21.	Change the heat load to Top Evaporator to 36Wand Bottom Evaporator to 108W (and run the loop for 3 hours)				
	Top: Inner ring: V* A= W Outer: ring: V* A= W total: W	Bottom: Inner ring: V* A= W Outer: ring: V* A= W total: W			
22.	Change the heat load to 72W for each evaporator (and run the loop for 1.5 hours)				
	Top: Inner ring: V* A= W Outer: ring: V* A= W total: W	Bottom: Inner ring: V* A= W Outer: ring: V* A= W total: W			
Switch on/off star tracker simulator and check evaporator temperature stability				LP-01, LP-02	
23.	Switch on star tracker simulator and run the loop for 20 minutes)				
	Voltage of star tracker heater: V	Current of star tracker heater: A			
24.	Switch off star tracker simulator and run the loop for 20 minutes				
25.	Switch on star tracker simulator and run the loop for 20 minutes)				
	Voltage of star tracker heater: V	Current of star tracker heater: A			

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Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
26.	Switch off star tracker simulator and run the loop for 20 minutes)					
27.	Switch on star tracker simulator and run the loop for 20 minutes)					
	Voltage of star tracker heater: V		Current of star tracker heater: A			
28.	Switch off star tracker simulator and run the loop for 20 minutes)					
Switch on/off cold orbit heater and check evaporator temperature stability					LP-01, LP-02	
29	Change the cold orbit heater control mode to manual and switch on cold orbit heater (and run the loop for 20 minutes)					
	Voltage of cold orbit heater: V		Current of cold orbit heater: A			
30.	Switch off the cold orbit heater (and run the loop for 20 minutes)					
31.	Switch on the cold orbit heater (and run the loop for 20 minutes)					
	Voltage of cold orbit heater: V		Current of cold orbit heater: A			
32.	Switch off the cold orbit heater (and run the loop for 20 minutes)					
33.	Switch on the cold orbit heater (and run the loop for 20 minutes)					
	Voltage of cold orbit heater: V		Current of cold orbit heater: A			
34.	Switch off the cold orbit heater					
35.	Change the cold orbit heater control mode to auto (and run the loop for 20 minutes)					
Switch on/off start-up heater and check evaporator temperature stability					LP-01, LP-02	
36.	Switch on the start-up heater (and run the loop for 20 minutes)					
	Voltage of start-up heater: V		Current of start-up heater: A			
37.	Switch off the start-up heater (and run the loop for 20 minutes)					
38.	Switch on the start-up heater (and run the loop for 20 minutes)					


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:	
Test engineer:			QA:		
Step No.	Action and Description		Comments	Req.	Time
	Voltage of start-up heater: V	Current of start-up heater: A			
39.	Switch off the start-up heater (and run the loop for 20 minutes)				
40.	Switch on the start-up heater (and run the loop for 20 minutes)				
	Voltage of start-up heater: V	Current of start-up heater: A			
41.	Switch off the start-up heater (and run the loop for 20 minutes)				
Loop stability and responses check to the rapid change of condenser temperature				LP-15	
42.	Increase the cold plates temperature				
	Ram T increasing rate: K/s	Wake T increasing rate: K/s			
43.	Decrease the cold plates temperature				
	Ram T decreasing rate: K/s	Wake T decreasing rate: K/s			
SHUT DOWN THE LOOP					
44.	Turn off the tracker heater load				
45	Turn off pre-heaters				
46.	Turn off the pump				
47.	Turn off accumulator T control				
48.	Shut down the cold orbit heater control				
49.	Change the bench-top climate chamber temperature to the lowest value of the hottest orbit +5K temperature profile; change the walk-in climate chamber to 15°C				
	Walk-in chamber T:	Bench-top chamber T:			
50.	Change the cold plate temperature profile to hottest orbit +5K case (closest the critical point operation				


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
	Ram T:		Wake T:			
51.	Change the USS temperature to 30°C					
	USS temperature profile:					
52.	Start accumulator T control				LP-22, PW-06	
	Tset(°C):	Max heating power(W):	Max cooling power(W):			
	APS(bar):				LP-28	
53.	Check the subcooling ΔT(°C):				LP-26	
54.	Start pump control and run the pump at 7500rpm				LP-29, PW-01	
	Voltage(V):	Current(A):	DPS(mbar)			
55.	Change the set-point to 15°C					
	Tset(°C):	Max heating power(W):	Max cooling power(W):			
56.	Switch on the pre-heaters					
	Top pre-heater:	V* A= W	Bottom pre-heater :	V* A= W		
57.	Set the cold orbit heater control to the auto mode				LP-25, PW-03	
58.	Turn on the tracker heat load of 144W and run the loop for 3 hours					
	Top:		Bottom:			
	Inner ring:	V* A= W	Inner ring:	V* A= W		


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
	Outer: ring: V* A= W total: W	Outer: ring: V* A= W total: W				
<i>Heater imbalance test</i>				LP-16		
59.	Change the heat load to Top Evaporator to 108Wand Bottom Evaporator to 36W (and run the loop for 3 hours)					
	Top: Inner ring: V* A= W Outer: ring: V* A= W total: W	Bottom: Inner ring: V* A= W Outer: ring: V* A= W total: W				
60.	Change the heat load to Top Evaporator to 36Wand Bottom Evaporator to 108W (and run the loop for 3 hours)					
	Top: Inner ring: V* A= W Outer: ring: V* A= W total: W	Bottom: Inner ring: V* A= W Outer: ring: V* A= W total: W				
61.	Change the heat load to 72W for each evaporator (and run the loop for 1.5 hours)					
	Top: Inner ring: V* A= W Outer: ring: V* A= W total: W	Bottom: Inner ring: V* A= W Outer: ring: V* A= W total: W				
62.	Turn off the tracker heat load simulator					


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Test engineer:		QA:			
Step No.	Action and Description		Comments	Req.	Time
63.	Turn off the pre-heaters				
64.	Turn off the pump				
65.	Shut down the USS T control				
66.	Shut down the cold orbit heater control				
67.	Turn off the cold plates T control				
68.	Set the bench-top climate chamber to 25°C (and run it for 2 hours); set the walk-in climate chamber to 25°C (and run it for 4 hours)				
	Bench-top chamber Tset:	Walk-in chamber Tset:			
69.	Shut down the bench top chamber				
70.	Shut down the walk-in chamber				
71.	Turn off the data-acquisition and control system				
72.	Backup test data				

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10.3 Coldest orbit/coldest orbit -11Kest

TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:		QA:				
Step No.	Action and Description			Comments	Req.	Time
	START-UP					
1.	Record environment conditions					
	Temperature: °C	Humidity: %RH	Pressure: mbar			
2	Check T and P sensors					
	T sensors:		P sensors:			
3	Check heaters/TEC					
	Pre-heater:	Cold orbit heater:	Accumulator Heater:			
	Top: Ω	Ram : Ω	Operation heater: Ω			
	Bottom: Ω	Wake: Ω	Emergency heater: Ω			
	Start-up heater: Ω	Liquid line health heater: Ω	TEC: Ω			
4	Turn on the data-acquisition and control system					
5.	Run climate chambers					
	Walk-in Chamber:		Bench-top Chamber:			
6.	Run cold plates (temperature profile document No.)					


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
	Ram temperature profile:		Wake temperature profile:			
7.	Start USS temperature control and run USS					
	USS temperature profile(or profile document):					
8.	Start accumulator T control				LP-22, PW-06	
	Tset: <input type="checkbox"/>	Max heating power: W	Max cooling power: W			
	APS(bar):				LP-28	
9.	Check the subcooling: ΔT= <input type="checkbox"/>					
10.	Start pump control and run pump 3000rpm				LP-26, PW-01	
	Voltage: V	Current: A	DPS: mbar			
11.	Switch on the pre-heaters				LP-23, PW-02	
	Top : V* A= W	Bottom: V* A= W				
12.	Start the cold orbit heater manual control mode				LP-25, PW-03	
13.	Check the pump inlet temperature T _{PI} (<input type="checkbox"/>):					
14.	Check the evaporator inlet temperature.					
	Top inlet T (<input type="checkbox"/>):		Bottom inlet T (<input type="checkbox"/>):			
15.	If evaporator inlet T is lower than -20 <input type="checkbox"/> , switch on start-up heater, else, set pump speed to 5000rpm					
	Start-up heater: V* A= W	DPS(mbar):				
16.	Check the pump inlet temperature T _{PI} (<input type="checkbox"/>):					

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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
17.	Check the evaporator inlet temperature					
	Top inlet T (□):		Bottom inlet T (□):			
18.	If evaporator inlet T is lower than -20□ and the start-up heater is off, switch on start-up heater, else, set pump speed to 5000rpm					
	Start-up heater:	V* A= W	DPS(mbar):			
19.	If evaporator inlet T is lower than -20□, and the cold orbit heater is off, switch on cold orbit heater, else, set pump speed to 5000rpm					
	Cold orbit heater:	V* A= W	DPS(mbar):			
20.	Change the accumulator temperature to T _{SET} =-15□					
	Tset (□):	Max heating power (W):	Max cooling power (W):			
21.	Check the occurrence of overheating			Notice two phase CO2 flow into the evaporators		
	Max Overheating ΔT(□):		Overheating time (s):			
22.	Turn on the Tracker heat load of 144W					
	Top: Inner ring: V* A= W Outer: ring: V* A= W total: W		Bottom: Inner ring: V* A= W Outer: ring: V* A= W total: W			
23.	Turn off the start-up heater if it is on					
24.	Switch the cold orbit heater control mode to manual, and run the loop for 3 hours					


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
	TEST PART					
	Check the pressure drop at different pump speeds (3000, 5000, 7500, 10000rpm)				LP-13, LP-06, PW-01	
25.	Change the pump speed to 3000rpm (and run the loop for 1.5 hours)					
	ΔPloop: mbar		DPS: mbar			
26.	Change the pump speed to 5000rpm (and run the loop for 10 minutes)					
	ΔPloop: mbar		DPS: mbar			
27.	Change the pump speed to 7500rpm (and run the loop for 10 minutes)					
	ΔPloop: mbar		DPS: mbar			
28.	Change the pump speed to 10000rpm (and run the loop for 10 minutes)					
	ΔPloop: mbar		DPS: mbar			
29.	Change the pump speed to 5000rpm (and run the loop for 0.5 hours)					
	ΔPloop: mbar		DPS: mbar			
	Heater imbalance test				LP-16	
30.	Change the heat load to Top Evaporator to 108Wand Bottom Evaporator to 36W (and run the loop for 3 hours)					
	Top: Inner ring: V* A= W		Bottom: Inner ring: V* A= W			


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
	Outer: ring: V* A= W total: W	Outer: ring: V* A= W total: W				
31.	Change the heat load to Top Evaporator to 36Wand Bottom Evaporator to 108W (and run the loop for 3 hours)					
	Top: Inner ring: V* A= W Outer: ring: V* A= W total: W	Bottom: Inner ring: V* A= W Outer: ring: V* A= W total: W				
32.	Change the heat load to 72W for each evaporator (and run the loop for 1.5 hours)					
	Top: Inner ring: V* A= W Outer: ring: V* A= W total: W	Bottom: Inner ring: V* A= W Outer: ring: V* A= W total: W				
Switch on/off start-up heater and check evaporator temperature stability					LP-01, LP-02	
33.	Switch on start-up heater and run the loop for 20 minutes)					
	Voltage of start-up heater: V	Current of start-up heater: A				
34.	Switch off start-up heater and run the loop for 20 minutes					
35.	Switch on start-up heater and run the loop for 20 minutes)					
	Voltage of start-up heater: V	Current of start-up heater: A				
36.	Switch off start-up heater and run the loop for 20 minutes)					
37.	Switch on start-up heater and run the loop for 20 minutes)					

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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST			TEST DATE:		
Test engineer:		QA:			
Step No.	Action and Description		Comments	Req.	Time
	Voltage of start-up heater: V	Current of start-up heater: A			
38.	Switch off start-up heater and run the loop for 20 minutes)				
Loop stability and responses check to the rapid change of condenser temperature				LP-15	
39.	Increase the cold plates temperature				
	Ram T increasing rate: K/s	Wake T increasing rate: K/s			
40.	Decreases the cold plates temperature				
	Ram T decreasing rate: K/s	Wake T decreasing rate: K/s			
	SHUT DOWN THE LOOP				
41.	Turn off the tracker heater load				
42.	Turn off pre-heaters				
43.	Turn off the pump				
44.	Turn off accumulator T control				
45.	Shut down the cold orbit heater control				
46.	Change the bench-top climate chamber temperature to the lowest value of the coldest orbit -11K temperature profile				
	Walk-in chamber T:	Bench-top chamber T:			
47.	Change the cold plate temperature profile to coldest orbit -11K case (closest the critical point operation				
	Ram T:	Wake T:			
48.	Change the USS temperature to-10°C				
	USS temperature profile:				


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
49.	Start accumulator T control				LP-22, PW-06	
	Tset(°C):	Max heating power(W):	Max cooling power(W):			
	APS(bar):				LP-28	
50.	Check the subcooling ΔT(°C):					
51.	Start pump control and run the pump at 3000rpm				LP-29	
	Voltage(V):	Current(A):	DPS(mbar)			
52.	Switch on the pre-heater					
	Voltage of pre-heater (V):		Current of pre-heater (A):			
53.	Start the cold orbit heater manual control mode					
54.	Check the pump inlet temperature T _{PI} = (°C)					
55.	Check the evaporator inlet temperature.					
	Top inlet T (°C):		Bottom inlet T (°C):			
56.	If evaporator inlet T is lower than -20□, switch on start-up heater, else, set pump speed to 5000rpm					
	Start-up heater (W):		DPS(mbar):			
57.	Check the pump inlet temperature T _{PI} (°C):					
58.	Check the evaporator inlet temperature					
	Top inlet T (°C):		Bottom inlet T (°C):			
59.	If evaporator inlet T is lower than -20□ and the start-up heater is off, switch on start-up heater, else, set pump speed to 5000rpm					


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
	Start-up heater:	V* A= W	DPS(mbar):			
60.	If evaporator inlet T is lower than -20°C, and the cold orbit heater is off, switch on cold orbit heater, else, set pump speed to 5000rpm					
	Cold orbit heater:	V* A= W	DPS(mbar):			
61.	Change the accumulator temperature to T _{SET} =-15°C					
	Tset (°C):	Max heating power (W):	Max cooling power (W):			
62.	Check the occurrence of overheating			Notice two phase CO2 flow into the evaporators		
	Max Overheating ΔT(°C):		Overheating time (s):			
63.	Turn on the Tracker heat load of 144W					
	Top Evaporator: Inner ring: V* A= W Outer: ring: V* A= W total:					


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:	
Test engineer:			QA:		
Step No.	Action and Description		Comments	Req.	Time
66.	Change the pump speed to 5000rpm (and run the loop for 10 minutes)				
	ΔP_{loop} : mbar	DPS: mbar			
67.	Change the pump speed to 7500rpm (and run the loop for 10 minutes)				
	ΔP_{loop} : mbar	DPS: mbar			
68.	Change the pump speed to 10000rpm (and run the loop for 10 minutes)				
	ΔP_{loop} : mbar	DPS: mbar			
69.	Change the pump speed to 5000rpm (and run the loop for 0.5 hours)				
	ΔP_{loop} : mbar	DPS: mbar			
<i>Heater imbalance test</i>				LP-16	
70.	Change the heat load to Top Evaporator to 108W and Bottom Evaporator to 36W (and run the loop for 3 hours)				
	Top: Inner ring: V* A= W Outer: ring: V* A= W total: W	Bottom: Inner ring: V* A= W Outer: ring: V* A= W total: W			
71.	Change the heat load to Top Evaporator to 36W and Bottom Evaporator to 108W (and run the loop for 3 hours)				
	Top: Inner ring: V* A= W	Bottom: Inner ring: V* A= W			


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
	Outer: ring: V* A= W total: W	Outer: ring: V* A= W total: W				
72.	Change the heat load to 72W for each evaporator (and run the loop for 1.5 hours)					
	Top: Inner ring: V* A= W Outer: ring: V* A= W total: W	Bottom: Inner ring: V* A= W Outer: ring: V* A= W total: W				
73.	Turn off the tracker heat load simulator					
74	Turn off the pump					
75.	Turn off the pre-heater					
76.	Shut down the cold orbit heater control					
77.	Shut down the accumulator T control					
78.	Set the bench-top climate chamber to 25°C (and run it for 2 hours); set the walk-in climate chamber to 25°C (and run it for 4 hours)					
	Bench-top chamber Tset:	Walk-in chamber Tset:				
79.	Shut down the bench top chamber					
80	Shut down the walk-in chamber					
81.	Turn off the data-acquisition and control system					
82.	Backup test data					


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10.4 Set-point change test

TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:		QA:				
Step No.	Action and Description			Comments	Req.	Time
	START-UP					
1.	Record environment conditions					
	Temperature: °C	Humidity: %RH	Pressure: mbar			
2	Check T and P sensors					
	T sensors:		P sensors:			
3	Check heaters/TEC					
	Pre-heater:	Cold orbit heater:	Accumulator Heater:			
	Top: Ω	Ram : Ω	Operation heater: Ω			
	Bottom: Ω	Wake: Ω	Emergency heater: Ω			
	Start-up heater: Ω	Liquid line health heater: Ω	TEC: Ω			
4	Turn on the data-acquisition and control system					
5.	Run climate chambers					
	Walk-in Chamber:		Bench-top Chamber:			


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
6.	Run cold plates (temperature profile document No.)					
	Ram temperature profile:		Wake temperature profile:			
7.	Start USS temperature control and run USS					
	USS temperature profile(or profile document):					
8.	Start accumulator T control					
	Tset: °C	Max heating power: W	Max cooling power: W			
9.	Check the subcooling: ΔT= °C					
10.	Start pump control and run pump at 3000rpm				LP-29	
	Voltage: V	Current: A	DPS: mbar			
11.	Switch on the pre-heaters					
	Top: Inner ring: V* A= W Outer: ring: V* A= W total: W		Bottom: Inner ring: V* A= W Outer: ring: V* A= W total: W			
12.	Start the cold orbit heater manual control mode					
13.	Check the pump inlet temperature T _{PI} (°C):					
14.	Check the evaporator inlet temperature.					


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
	Top inlet T (°C):		Bottom inlet T (°C):			
15.	If evaporator inlet T is lower than -20□, switch on start-up heater, else, set pump speed to 5000rpm					
	Start-up heater: V* A= W		DPS(mbar):			
16.	Check the pump inlet temperature T _{PI} (°C):					
17.	Check the evaporator inlet temperature					
	Top inlet T (°C):		Bottom inlet T (°C):			
18.	If evaporator inlet T is lower than -20□ and the start-up heater is off, switch on start-up heater, else, set pump speed to 5000rpm					
	Start-up heater: V* A= W		DPS(mbar):			
19.	If evaporator inlet T is lower than -20□, and the cold orbit heater is off, switch on cold orbit heater, else, set pump speed to 5000rpm					
	Cold orbit heater: V* A= W		DPS(mbar):			
20.	Change the accumulator temperature to T _{SET} =-15°C					
	Tset (°C):		Max heating power (W):		Max cooling power (W):	
21.	Check the occurrence of overheating			Notice two phase CO2 flow into the evaporators		
	Max Overheating ΔT(°C):		Overheating time (s):			
22.	Turn on the Tracker heat load of 144W					
	Top: Inner ring: V* A= W		Bottom: Inner ring: V* A= W			

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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:		QA:				
Step No.	Action and Description			Comments	Req.	Time
	Outer: ring: V* A= W total: W	Outer: ring: V* A= W total: W				
	TEST PART					
23.	Turn off the start-up heater if it is on and run the loop for 3 hours					
24.	Change climate chambers temperature					
	Walk-in Chamber:	Bench-top Chamber:				
25.	Change cold plates temperature profile (to the nominal operation)					
	Ram temperature profile:	Wake temperature profile:				
26.	Change USS temperature to 5°C					
27.	Change the set-point to T _{SET} = 0°C				LP-05,LP-22, PW-06	
	Tset: °C	Max heating power: W	Max cooling power: W			
28.	Check T _{SET} =0°C					
29.	Change climate chambers temperature					
	Walk-in Chamber:	Bench-top Chamber:				
30.	Change cold plates temperature profile (to hottest orbit cases)					
	Ram temperature profile:	Wake temperature profile:				


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
31.	Change USS temperature to 25°C					
32.	Change the set-point to T _{SET} =15°C				LP-05,LP-22, PW-06	
	Tset: °C	Max heating power: W	Max cooling power: W			
33.	Check T _{SET} =15°C					
34.	Change climate chambers temperature					
	Walk-in Chamber:		Bench-top Chamber:			
35.	Change cold plates temperature profile (to the nominal operation)					
	Ram temperature profile:		Wake temperature profile:			
36.	Change USS temperature to 5°C					
37.	Change the set-point to T _{SET} = 0°C				LP-05,LP-22, PW-06	
	Tset: °C	Max heating power: W	Max cooling power: W			
38.	Check T _{SET} =0°C					
39.	Change climate chambers temperature					
	Walk-in Chamber:		Bench-top Chamber:			


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
40.	Change cold plates temperature profile (to the coldest orbit case)					
	Ram temperature profile:		Wake temperature profile:			
41.	Change USS temperature to -5°C					
42.	Change the set-point to T _{SET} =-15°C				LP-05,LP-22, PW-06	
	Tset: °C	Max heating power: W	Max cooling power: W			
43.	Check pump inlet temperature T _{PI} = 0°C					
44.	Start cold orbit heater control and turn it on when pump inlet temperature is less than -25°C					
	Voltage of cold orbit heater (V):		Current of cold orbit heater (A):			
45.	Check set-point T _{SET} =-15°C					
46.	Turn off the heat load					
47.	Turn off the pre-heater					
48.	Turn off the cold orbit heater control					
49.	Turn off the pump					
50.	Turn off the accumulator T control					
51.	Turn off the cold plates T control					
52.	Set the bench-top climate chamber to 25°C (and run it for 2 hours); set the walk-in climate chamber to					


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:		QA:				
Step No.	Action and Description			Comments	Req.	Time
	25°C (and run it for 4 hours)					
	Bench-top chamber Tset:		Walk-in chamber Tset:			
53.	Shut down the bench top chamber					
54.	Shut down the walk-in chamber					
55.	Turn off the data-acquisition and control system					
56.	Backup test data					


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10.5 Supercritical pump start up

TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:		QA:				
Step No.	Action and Description			Comments	Req.	Time
	START-UP					
1.	Record environment conditions					
	Temperature: °C	Humidity: %RH	Pressure: mbar			
2	Check T and P sensors					
	T sensors:		P sensors:			
3	Check heaters/TEC					
	Pre-heater:	Cold orbit heater:	Accumulator Heater:			
	Top: Ω	Ram : Ω	Operation heater: Ω			
	Bottom: Ω	Wake: Ω	Emergency heater: Ω			
	Start-up heater: Ω	Liquid line health heater: Ω	TEC: Ω			
4	Turn on the data-acquisition and control system					
5.	Run climate chambers					
	Walk-in Chamber:		Bench-top Chamber:			


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
6.	Run cold plates (temperature profile document No.)					
	Ram temperature profile:		Wake temperature profile:			
7.	Start USS temperature control and run USS at 35°C					
	USS temperature profile(or profile document):					
8.	Start start-up radiator simulator T control and run it at 35°C					
9.	Check the pump temperature T _p = °C				LP-29	
10.	Turn off the start-up radiator simulator T control					
11.	Start pump control and run the pump at 3000rpm					
	Voltage of pump (V):	DP (mbar):	DPS (mbar):			
12.	Check CO2 flowing in the loop			Based on changes of the temperatures along the loop		
	Yes:		No:			
13.	If no CO2 flow in the loop, change the pump speed to 5000rpm					
	Voltage of pump (V):	DP (mbar):	DPS (mbar):			
14.	Check CO2 flowing in the loop					
	Yes:		No:			
15.	If no CO2 flow in the loop, change the pump speed to 7500rpm					
	Voltage of pump (V):	DP (mbar):	DPS (mbar):			

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10.6 RC responses to the heaters (with Fr=0g/s)

TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:		
Test engineer:			QA:			
Step No.	Action and Description			Comments	Req.	Time
	START-UP					
1.	Record environment conditions					
	Temperature: °C	Humidity: %RH	Pressure: mbar			
2	Check T and P sensors					
	T sensors:		P sensors:			
3	Check heaters/TEC					
	Pre-heater:	Cold orbit heater:	Accumulator Heater:			
	Top: Ω	Ram : Ω	Operation heater: Ω			
	Bottom: Ω	Wake: Ω	Emergency heater: Ω			
	Start-up heater: Ω	Liquid line health heater: Ω	TEC: Ω			
4	Turn on the data-acquisition and control system					
5.	Run climate chambers					
	Walk-in Chamber:		Bench-top Chamber:			
6.	Check the temperature stability of the loop					


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST			TEST DATE:		
Test engineer:		QA:			
Step No.	Action and Description		Comments	Req.	Time
	Max ΔT in 10 minutes: °C				
7.	Turn on the start-up heater				
	Voltage of the heater (V):	Current of the heater (A):			
8.	Check the heater temperature, turn off start-up heater when its temperature become stable or reach 60°C				
	Max heater temperature: °C	Stable heater temperature			
9.	Check the temperature stability of the loop				
	Max ΔT in 10 minutes: °C				
10.	Turn on the cold orbit heater				
	Voltage of the heater (V):	Current of the heater (A):			
11.	Check the heater temperature, turn off cold orbit heater when its temperature become stable or reach 60°C				
	Max heater temperature: °C	Stable heater temperature			
12.	Check the temperature stability of the loop				
	Max ΔT in 10 minutes: °C				
13.	Turn on the star tracker heater				
	Voltage of the heater (V):	Current of the heater (A):			
14.	Check the heater temperature, turn off star tracker heater when its temperature become stable or reach 60				


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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:	
Test engineer:			QA:		
Step No.	Action and Description		Comments	Req.	Time
	°C				
	Max heater temperature: °C	Stable heater temperature			
15.	Change the climate chambers temperature				
	Walk-in Chamber:	Bench-top Chamber:			
16.	Check the temperature stability of the loop				
	Max ΔT in 10 minutes: °C				
17.	Turn on the start-up heater				
	Voltage of the heater (V):	Current of the heater (A):			
18.	Check the heater temperature, turn off start-up heater when its temperature become stable or reach 60°C				
	Max heater temperature: °C	Stable heater temperature			
19.	Check the temperature stability of the loop				
	Max ΔT in 10 minutes: °C				
20.	Turn on the cold orbit heater				
	Voltage of the heater (V):	Current of the heater (A):			
21.	Check the heater temperature, turn off cold orbit heater when its temperature become stable or reach 60 °C				
	Max heater temperature: °C	Stable heater temperature			

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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:	
Test engineer:			QA:		
Step No.	Action and Description		Comments	Req.	Time
22.	Check the temperature stability of the loop				
	Max ΔT in 10 minutes: °C				
23.	Turn on the star tracker heater				
	Voltage of the heater (V):	Current of the heater (A):			
24.	Check the heater temperature, turn off star tracker heater when its temperature become stable or reach 60 °C				
	Max heater temperature: °C	Stable heater temperature			
25.	Change climate chambers temperature				
	Walk-in Chamber:	Bench-top Chamber:			
26.	Check the temperature stability of the loop				
	Max ΔT in 10 minutes: °C				
27.	Turn on the start-up heater				
	Voltage of the heater (V):	Current of the heater (A):			
28.	Check the heater temperature, turn off start-up heater when its temperature become stable or reach 60°C				
	Max heater temperature: °C	Stable heater temperature			
29.	Check the temperature stability of the loop				
	Max ΔT in 10 minutes: °C				

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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST				TEST DATE:	
Test engineer:			QA:		
Step No.	Action and Description		Comments	Req.	Time
30.	Turn on the cold orbit heater				
	Voltage of the heater (V):	Current of the heater (A):			
31.	Check the heater temperature, turn off cold orbit heater when its temperature become stable or reach 60 °C				
	Max heater temperature: °C	Stable heater temperature			
32.	Check the temperature stability of the loop				
	Max ΔT in 10 minutes: °C				
33.	Turn on the star tracker heater				
	Voltage of the heater (V):	Current of the heater (A):			
34.	Check the heater temperature, turn off star tracker heater when its temperature become stable or reach 60 °C				
	Max heater temperature: °C	Stable heater temperature			
35.	Set the bench-top climate chamber to 25°C (and run it for 2 hours); set the walk-in climate chamber to 25°C (and run it for 4 hours)				
	Bench-top chamber Tset:	Walk-in chamber Tset:			
36.	Shut down the bench top chamber				
37.	Shut down the walk-in chamber				

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TTCS EM TEST PROCEDURE FOR 2ND LOOP MICRO-G TEST		TEST DATE:		
Test engineer:		QA:		
Step No.	Action and Description	Comments	Req.	Time
38.	Turn off the data-acquisition and control system			
39.	Backup test data			

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